



# Age of Ground Water in the Kanawha-New and Allegheny- Monongahela River Basins

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# Introduction

- † Wells were sampled for chlorofluorocarbons (CFC's) from the Appalachian Plateaus Physiographic Province within the Kanawha-New and Allegheny-Monongahela River Basins of West Virginia, Maryland, and Pennsylvania.
- † Wells sampled were primarily domestic homeowner and small public supply wells.
- † CFC data was used to compute the age of the ground water in the wells sampled.

# CFC Ground Water Age Dating

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- † Chlorofluorocarbons (CFC's) were developed in the 1930's.
- † CFC production and use has steadily increased since they were developed.
- † First detectable concentrations of CFC's in the atmosphere occurred around 1940.
- † CFC's can be used to date ground water.

# Henry's Law

- †  $C_i = K_h \times P_i$  where
- †  $C_i$  is concentration in equilibrium with air in pm/kg (picomoles per kilogram).
- †  $K_h$  is the Henry's Law constant, and
- †  $P_i$  is the partial pressure of a gas in air.  $P_i$  is expressed as a volume fraction in parts per trillion (pptv).

# Topics of Discussion

- † How Old is Ground Water in the Kanawha-New and Allegheny-Monongahela River Basins?
- † What Factors Affect the Age of Ground Water in the region?
- † How does mining affect age of ground water in fractured bedrock aquifers?

# Age of Ground Water in the Kanawha-New River Basin

- † Water from hilltop wells ranged from 11 to 19 years and averaged 13 years in age.
- † Water from hillside wells ranged from 10 to 42 years and averaged 29 years in age.
- † Water from valley wells ranged from 19 to >57 years and averaged 42 years in age.

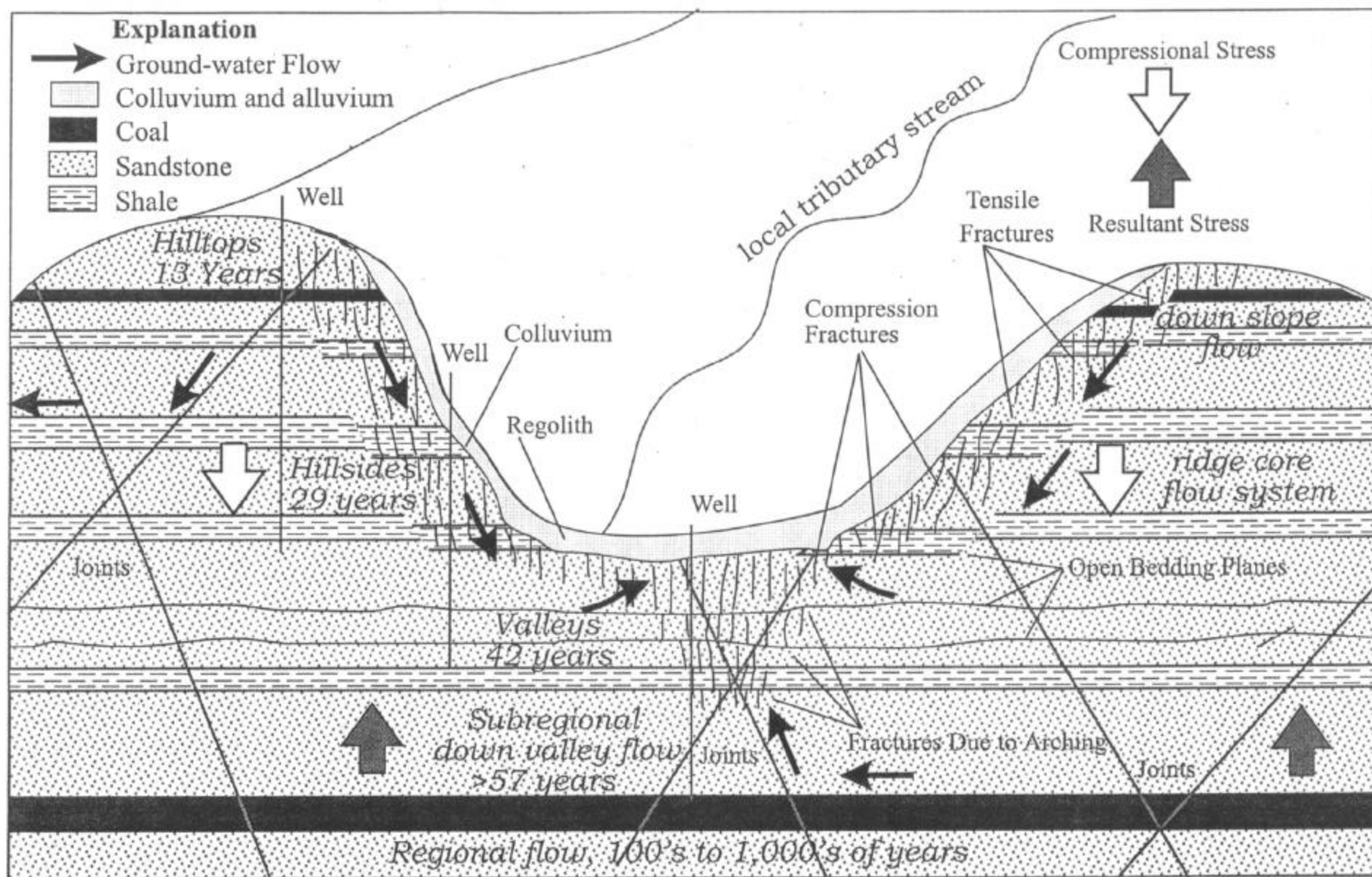


Figure 3. Revised conceptual model of ground-water flow in an Appalachian Plateaus fractured-bedrock aquifer including apparent age of ground water (Modified from Wyrick and Borchers, fig. 3.2-1, 1981 and Kozar, 1998).

# Age of Ground Water in mined areas of the Kanawha-New River basin

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- † Hilltop wells could not be located for sampling as that portion of the hydrologic flow system typically is disturbed.
- † Water from hillside wells ranged from 10 to 47 years and averaged 27 years in age.
- † Water from valley wells ranged from 4 to >58 years and averaged 32 years in age.



# Age of Ground Water in mined areas of the Allegheny-Monongahela basin

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- † Water from hilltop wells could not be located in that portion of the hydrologic flow system which typically is disturbed.
- † Water from hillside wells ranged from 11 to 57 years and averaged 30 years in age.
- † Water from valley wells ranged from 13 to >57 years and averaged 29 years in age.

# Factors Affecting Age of Ground Water in the Region

- † Topographic Setting (Water from valley wells is oldest, from hilltop wells is youngest, and from hillside wells is intermediate in age).
- † No other factors including well depth, well yield, length of casing, water level, and distance from recharge area were found to be correlated with ground water age.

# Possible Factors Affecting Age of Ground Water in Mined Areas

- † Lack of distinct topographic effects in the Allegheny-Monongahela basin may be due to lower relief and/or rolling topography.
- † Surface mining may have altered normal ground-water flow patterns.
- † Younger age of ground water in mined areas may be reflective of increased ground-water flow velocity due to enhanced permeability.

# What this Means

- † Ground water in the region is much older than previously thought.
- † Ground-water travel times within the region are therefore much longer than previously thought.
- † Surface mining may alter natural ground-water flow processes resulting in increased ground-water flow velocity (younger age).

# Implications and Applications

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- † Conceptual models of ground water flow in fractured bedrock aquifers of the Appalachian Plateaus need to be revised based on the information revealed by CFC age dating.
- † Regulations designed to protect ground water resources must address longer travel and residence times for ground water in fractured bedrock aquifers of the region.

# Future Considerations

- † Additional data is needed to understand ground-water flow and age of ground water in deeper portions of the Appalachian Plateaus aquifers, especially in fractured bedrock below ridge tops.
- † CFC data is also needed in areas of active surface and underground mining, especially in hilltop settings.